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NPIC/D-24-70

20 FEB 1970

MEMORANDUM FOR: Deputy Director of Intelligence

SUBJECT : Proposed Contract with [REDACTED]
for a Power Spectral Density Quality
Measure Study at a Cost of [REDACTED]

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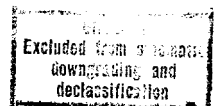
1. This memorandum requests approval for the commitment of funds for a contract. The specific request is stated in Paragraph 7.

2. a. The proposed contract deals with a new technique for determining an objective measure of image quality in photographic and optical systems. Currently within NPIC, image quality of missions, optical viewing equipment, and photographic reproductions is assessed largely on the basis of individual experience and a numerical observation called resolving power or ground resolution. The resolving power is obtained from known geometric targets imaged by the recording system. It is determined by observation of the smallest recognizable element of the target and is intended to reflect overall system ability to image fine details. NPIC Photographic Evaluation Reports discuss image quality in narrative terms: i.e., "good, poor, better than," etc. These reports also present tables of auxiliary, numerical data, including resolving power. No attempt is made in the report to reconcile the image quality criteria beyond this point; this is left to the reader to judge in his particular context.

b. Use of the system ground resolution as a qualitative indicator of performance is justified with suitable constraints; however, as a quantitative summary measure of merit for technical purposes, it is notoriously inadequate. Just as horsepower alone is no longer a suitable descriptor of new car performance, so resolving power is not sufficient for comparative image evaluation. Neither is uniquely related to the critical variables of the system.

c. As a consequence, image evaluation is more an art than a science, and a gap exists between subjective judgements and the objective measures necessary for system specification, design, and quantitative analysis. A step

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toward the solution is the augmentation of resolution data with other system parameters and their experimental correlation with subjective responses. Until this objective is achieved, image quality evaluation will remain an essentially intuitive, unreliable, and unnecessarily costly procedure. This situation places undue reliance upon the contractor and restricts our ability to evaluate his results.

d. Recently, in recognition of the dilemma, a variety of techniques (e.g., modulation transfer function, modulation detectability response) has been developed to provide data for design, test, and evaluation engineers. While theoretically sound, the approximations, targets, time, and money required to implement them have resulted in little more than sophisticated techniques for estimating resolving power. As a result, they are not employed by NPIC. The proposed contract offers a technique that may overcome these limitations by analyzing the image power spectrum. This quantity is directly related to the image concerned, requires no special targets, and can be measured and evaluated using equipment currently under development.

3. a. Every image has a power spectrum (i.e., the amount of radiant energy at each spatial frequency) that is characteristic of its spatial high frequency content--the more high frequencies, the better the image definition, the sharper the edges. Employing a coherent optical system, evaluation of an image in terms of its Power Spectral Density (PSD) is an approach which overcomes the single numerical value problems associated with resolving power--it is two dimensional and does not require special targets. The necessary equipment is already in operation at []

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[] in connection with the Target Indexing Device in the NPIC Automatic Target Recognition (ATR) program. Thus, it is now possible to investigate the application of PSD techniques to image quality specification without having to invest money in more hardware and at the same time, extend the utility of the ATR program.

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b. The proposed project will be executed in four phases over a one-year period:

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- (1) optical system calibration and preliminary experiments with known images,
- (2) statistical design and software preparation,
- (3) experiments with operational images, and
- (4) data analysis and report preparation.

At the completion of Phase 1, the monthly technical report will include a recommendation as to whether or not the work should be continued with a detailed justification.

c. The concept of image quality assessment discussed in the proposal is based on published research and is well thought out; however, it has not been applied in this context. While there is no guarantee of success, a positive indication comes from the performance of the cloud detection device. The potential payoff is extremely significant; the relationship between objective analysis and subjective judgements of quality is basic to every aspect of the PI effort. Once established, it would save time and money and provide guidance for future development efforts. The proposed contract is considered to be worth the risk involved.

d. A comprehensive technical report and appropriate software will be delivered at the conclusion of the contract. The report will include detailed procedures for using image quality assessment programs during routine operation of the Target Indexing Device.

4. a. The unsolicited proposal from [] offers a unique opportunity to perform this applied research in a TKN facility without having to pay for the expensive coherent optical system and film handling equipment that would be required of any other contractor. No other proposals will be solicited. The estimated price of the work is [] These funds were programmed as part of the FY-70 budget.

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b. The project has been closely coordinated to insure that it will not conflict with the work presently underway in the ATR program.

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6. The sterility code [] is appropriate; the project officer will assign security classifications to the individual reports.

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7. It is requested that the negotiation with []
[] for a contract to conduct the program described
at a cost not to exceed [] be approved.

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ARTHUR C. LUNDAHL

Director

National Photographic Interpretation Center

Attachments:

1. Proposal
2. Form 2420

APPROVED:

R. J. SMITH

Deputy Director for Intelligence

Date

Distribution:

- Original - NFIC/TSSG/SC&PS (After approval)
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